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Altruism and vaccination intentions: Evidence from behavioral experiments

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ABSTRACT

Vaccine hesitancy has been on the rise throughout the past two decades, especially in high income countries where existing pro-vaccination public health communication strategies have proven ineffective. We argue that appealing to other-regarding preferences is one way of improving the effectiveness of public health communication strategies. To test this argument, we assess how vaccination intentions are influenced by the presence of people who cannot vaccinate, such as the immunosuppressed, newborns or pregnant women, using a laboratory experiment where there is a passive player whose welfare depends on the decisions of other, active players. Results suggest that pro-vaccine messages targeting altruism can increase vaccination intentions by: (i) invoking past experiences of dependence and vulnerability; (ii) stressing cooperation as a social norm; and (iii) emphasizing the presence of vulnerable individuals in a given society.

1. Introduction

Despite great progress in infectious disease control and prevention during the past century, infectious pathogens continue to pose a serious threat. This threat is clearly exemplified by the current CoVID-19 pandemic, but also by past experiences with SARS, H1N1 influenza, Ebola, and resurgent measles outbreaks, all of which have drastically disrupted everyday's life, diminished public health resources and dominated media headlines.

Vaccines, when available, represent one of the most significant, cost-effective and safe public health interventions capable of mitigating such outbreaks (Ehreth, 2003; Ozawa et al., 2012; Gessner et al., 2017). However, vaccine hesitancy has become alarmingly widespread over the last two decades, especially in higher income nations (Larson et al., 2016) where vaccine refusal has steadily increased, and routine immunisation coverage for infectious diseases, such as measles, has decreased over time (WHO, WHO-UNICEF coverage estimates, 2017). As a result of this trend, many wealthier countries increasingly find themselves struggling to contain measles outbreaks, with significant ramifications for public health (Mulholland et al., 2012). For example, in 2019, the United States reported its highest number of cases in 25 years, while four countries in Europe – Albania, the Czech Republic, Greece, and the United Kingdom – lost their measles elimination status in 2018 following protracted outbreaks (WHO, 2019).

The prevalence of vaccine refusal as well as subsequent re-emergence of measles and, more generally, vaccine preventable diseases (VPD) is partially associated with vaccine hesitancy. According to the WHO Strategic Group of Experts (MacDonald, 2015), vaccine hesitancy is a complex behavioral concept that is context and vaccine-specific, and defined as “a delay in acceptance or refusal of vaccines despite availability of vaccination services” (Bedford et al., 2018). Current attitudes toward vaccines in high income countries stem from a prolonged period of largely sub-optimal vaccine uptake that began in 1998, following a publication documenting a causal link between the trivalent vaccine

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against measles, mumps and rubella (MMR) and autism in children, which was later retracted for scientific fraud (Dyer, 2010). Despite the retraction, the paper resulted in a preponderance of sensationalised reports of adverse vaccine events (Fefferman et al., 2015).

Of great concern is not only the potential for vaccine hesitancy to undermine benefits of past immunisation efforts and eliminate herd immunity, but also the ability of rhetoric appealing to vaccine hesitancy to persist in the long term, despite authoritative dismissals (Madsen et al., 2002, Taylor et al., 2014). In response to the surge in vaccine hesitancy, public health authorities have released several technical reports that summarise and address concerns about vaccines, and have also developed interventions aimed at increasing vaccination rates (ECDC, 2017). Specifically, the WHO SAGE vaccine hesitancy working group and the European Centre for Disease Prevention and Control (WHO, 2014, ECDC, 2015a, b and 2016) find that, while reasons for vaccine hesitancy are multifaceted and vary across vaccines, time, and regions, the most widespread sources of vaccine hesitancy are: i) fear of vaccine side effects, ii) perceived low risk of vaccine preventable diseases (VPD), and iii) mistrust in health care providers. However, studies demonstrate that efforts to mitigate these sources of vaccine hesitancy typically prove unsuccessful and may even result in greater vaccine hesitancy (Nyhan et al. 2013, 2014, Nyhan and Reifler, 2015). In turn, many acknowledge additional factors need to be further explored to better address vaccine hesitancy (Holzmann and Wiedermann, 2019).

To this end, one approach to mitigating vaccine hesitancy that has received less attention is to trigger altruistic behavior. The idea is that prompting greater concern for others' welfare may lead individuals to vaccinate even when the coverage level is above herd immunity and the incentive to free-ride is high (Chapman et al., 2012; Shim et al., 2012). In a vaccination context, altruistic behavior can be evoked by drawing public attention to individuals who cannot vaccinate. Indeed, many categories like newborn babies or immunodepressed people, because of their medical conditions, are exempted from vaccination and are critically dependent on herd immunity and on the actions that other people take (among which, vaccinating) to protect themselves from the disease.

Empirical studies that link vaccination and altruism are limited and belong to a fairly recent line of research. Extant evidence points to a positive relationship between altruism and stated vaccination intentions (Shim et al., 2012). There are different factors that underpin this relationship.

For example, Böhm et al. (2016) suggest that making the vaccination context salient is critical to activating the link between altruism and vaccine uptake. In particular Böhm et al. (2016) develop an interactive vaccination game to compare uptake under neutral and a vaccination wording, documenting a positive effect of prosocial behaviours on vaccine uptake. In a controlled laboratory experiment, they show that prosocial individuals, i.e. those who also regard the outcomes of others in their decisions, are more likely to vaccinate than proself individuals, who focus solely on their own outcome. For instance, when framing the game as a vaccination decision, individuals' general attitude towards real-life vaccination predicts vaccine uptake in a supposedly artificial game.

Other studies emphasize the importance of communicating the implications of vaccinating, demonstrating that explanations of how vaccinating can reduce danger to vulnerable segments of the population increases vaccination intentions (Rieger, 2020). Vietri et al. (2012) show that individuals are sensitive to the amount of good they feel they are doing for others by vaccinating. That is, individual motivation for vaccinating is not entirely driven by a desire to protect others, but also by a desire to feel good about one's self.

This paper adds to our understanding of the relationship between altruism and vaccination intentions by offering insight into the different avenues through which altruism can impact vaccination intentions.

We expect that decisions to vaccinate can be motivated by a desire to protect vulnerable segments of the population that are unable to get vaccinated for medical reasons, such as those who are immunocompromised, or for safety concerns as is the case of newborns and pregnant women (Bergin et al., 2018). We also predict that the link between altruism and vaccination intentions will be stronger among those who were unable to vaccinate at some point in their own life. Built into this argument is an assumption that, because individuals are motivated by a desire to protect the health of those who are unable to vaccinate, the link between altruism and vaccination intentions will be stronger in a public health setting. That is, because people care about public health outcomes, we expect to see greater cooperation using a more explicit (i.e., vaccine-related) communication strategy rather than a neutral one. Finally, noting work on processing fluency, which shows that attitudes toward a message are impacted by the perceived ease of processing the message (Foster et al., 2013) and that reliance on details (i.e., numeric descriptors) to convey information makes message processing more difficult (Porumbescu et al., 2017), we expect that the inclusion of more details in a message will render it less effective when compared to simpler messages.

To empirically assess these expectations, we conducted a laboratory experiment with graduate students in an Italian University. We used this laboratory experiment also to test the effect of framing (vaccination vs. neutral) and the level of detail of the narratives (high detail and numerical vs. low detail and narrative). To thoroughly explore the determinants of the decision-making process we asked participants in the laboratory experiment to play thirty rounds of the game, either as active or passive players. The advantage of having players play multiple rounds of the game is that we are able to more closely approximate the way individuals learn from stimuli when making complex decisions in a real world setting. We revisit this issue later in the manuscript. As we explain, the results from the laboratory experiment highlight the importance of altruistic behavior in vaccination decisions and allow us to better disentangle the mechanisms in place.

The paper is structured as follows. Section 2 introduces our experimental methods and the laboratory experiment. Section 3 presents findings, and Section 4 discusses the main implications of the study.

2. Methods

To test our expectations, we conducted a laboratory game experiment using a sample of Italian university students, whereby subjects received monetary payoffs according to answers they gave and, as a consequence, the outcome of the game. This approach is supported by substantive evidence that choices made in simple games predict people's behavior with respect to real-world social choices (Charness and Rabin, 2002), even in the presence of a global pandemic (Campos-Mercade et al., 2020).

2.1. Two and three-player game

The proposed experiment consisted of a two- or three-player variant of the Hawk-Dove game (Neugebauer et al., 2008) with a risk dominant strategy (Fig. 1) and payoffs being the experimental tokens that players could earn. In the two-player game, both participants were active and could decide among two strategies that initially were framed in neutral terms (Choice 1 and Choice 2): a risk-free strategy that provides a positive externality for the other player (i.e., a co-operative strategy that provides the same payoff no matter what the other player does), and a risky strategy that pays off only if the other player is playing the risk-free strategy (i.e., a non-cooperative strategy that pays off only if the other person plays the co-operative strategy). In the three-player game, the third player had no choice (passive player) in the sense that he/she could not decide on the strategy and his/her final payoff was completely determined by the strategy chosen by the other two active players.

Both the two-player and three-player games have two pure Nash equilibria strategies where one player plays the cooperative action (Choice 1) and the other the selfish action (Choice 2). These are also the strategy profiles that players should aim for if they wanted to maximize

		Player B	
		Choice 1	Choice 2
Player A	Choice 1	5,5	5,10
	Choice 2	10,5	2,2

a) Two-Player Game

		Player B	
		Choice 1	Choice 2
Player A	Choice 1	5,5,5	5,10,2
	Choice 2	10,5,2	2,2,2

b) Three-Player Game

Fig. 1. Game with Neutral Wording. a) Original two-player game where the two players are both active; b) Three-player game where a third passive player is added and the payoffs of the two original active players are unchanged. In the online Supplementary material a version of this game with vaccination wording is presented where only the names of the actions change.

total social surplus, in the sense that they maximize the sum of all payoffs, even when the passive player is present.

Note first that, as payoffs do not change for the two active players when the third player is added, if those two active players are selfish, the Nash equilibria does not change in the three-player game.

Note also that there is a trade-off between what is best for the passive player and for society: the total surplus is higher (17 versus 15) if only one active player chooses the cooperative action but the passive player is much better off if both cooperate (5 versus 2). In addition, the game was designed to make the payoff difference between the uncooperative and the cooperative action very salient by assigning a payoff that is noticeably higher (two digits and double the cooperative payoff) for the free-rider action. Both of these design elements have been introduced to highlight the attractiveness of uncooperative behavior so that the cooperative choice can be more confidently interpreted as a sign of altruism.

The above design mimics the tradeoff between vaccinating and not vaccinating in a real-world decision context, even when the game is framed in neutral terms. There is a risk-free decision that is collaborative (representing vaccination) and a risky decision to free ride on the behavior of others (i.e. no vaccination). Both players are slightly better off if one cooperates and the other does not, when compared to what would happen if both cooperated. This is because the player who free-rides is protected by herd immunity while not incurring in any personal cost (i.e., risks associated to the vaccines). The worst outcome is obtained when no one cooperates. In the three-player version of the game, the passive player mimics those who cannot get vaccinated and relies on other people choosing the cooperative strategy to achieve herd immunity to keep their personal risk of getting infected under control. The best outcome for the passive player occurs when both active players cooperate, whereas the worst outcome occurs when no one cooperates. The two active players in the game are aware of the presence of the third passive player and the way that player's payoff depends on active players' cooperative or uncooperative actions.

In addition to the neutral framing, we also consider three other variants of the game where wording related to vaccination was made explicit (see online Supplementary material for details). The first variant of the game with vaccination wording labelled the two actions as *Vaccinate* and *Don't Vaccinate* instead of Choice 1 and Choice 2, respectively. In the other two variants of the game, a prompt on the importance of vaccination was shown to participants at the beginning of the session. In the first variant, the prompt had a non-technical framing with no numbers (low detail framing); in the second, a technical framing was used whereby some statistics were included in the message (high detail framing). All details about experimental instructions and prompts are in the online Supplementary material. In a real-world context, we imagine the two prompts (low and high details) act as two alternative types of vaccination campaign, with different levels of technical information.

2.2. Laboratory experiment design

Participants were students in an Italian university, recruited in April 2018 via an experimental laboratory recruitment system. Through the recruiting system, in the days preceding the actual experiment, subjects were asked to fill in a brief survey on individual characteristics that we believe could affect their behavior in the game, including demographics, health, and social preferences variables (Table A1 in the Appendix).

The experiment consisted of a mixed 2 (number of players: two or three) x 2 (framing: neutral or vaccination) x 3 (detail: no prompt, low detail prompt, high detail prompt) design (see also Table 1 below). Framing and detail were minor treatments of the experiment, we use them to control for robustness consistency and as a check for external validity of our results. Detail was used only in the context of the vaccination wording and was always a between-subjects factor in the sense that participants received at the beginning of the session one of the three detail control options (i.e.; either no prompt, low detail or high detail prompt).

The other two factors were between-subjects in some sessions and within-subjects in other sessions. In other words, we conducted sessions where participants played either the two-player or the three-player game with a change in framing after a given number of rounds; and sessions where framing was fixed but subjects played the two-player game for some rounds and the three-player game afterwards. The repetitive design of the laboratory experiment enabled us to also study the role of learning in the decision process, by having subjects play several rounds of the game with different major and minor treatments. During each laboratory session, subjects played thirty rounds of the game, divided into two parts, the first 9 rounds *(First block)* and the remaining

Table 1
Session Summary. For each of the 16 sessions we list the number of participants and the type of treatment, across two dimensions: number of players and framing. One of the dimensions was kept fixed, and the other varies after 9 or 10 rounds. We discuss in the Appendix why the first two sessions have 40 rounds.

Session number	Number of participants	Number of rounds	Game type (# players)	Type of Wording	Level of Detail in the Prompt
1	24	10 + 30	2	Neutral, then vaccination	–
2	26	10 + 30	2	Neutral, then vaccination	High
3	18	9 + 21	3	Neutral, then vaccination	–
4	27	9 + 21	3	Neutral, then vaccination	High
5	27	9 + 21	3	Neutral, then vaccination	Low
6	24	9 + 21	2-to-3	Neutral	–
7	18	9 + 21	2-to-3	Vaccination	–
8	24	9 + 21	2-to-3	Vaccination	High
9	24	9 + 21	2-to-3	Vaccination	Low
10	24	9 + 21	2-to-3	Neutral	–
11	24	9 + 21	3	Neutral, then vaccination	Low
12	24	9 + 21	3	Neutral, then vaccination	High
13	18	9 + 21	2-to-3	Neutral	–
14	24	9 + 21	2-to-3	Vaccination	Low
15	24	9 + 21	2-to-3	Neutral	–
16	24	9 + 21	2-to-3	Vaccination	High

21 rounds *(Second block)*, with a single change of the features of the game in between: in each session, either the number of players varied and the framing was kept unchanged, or framing varied and the number of players was kept unchanged.

For the two-to-three player games, the wording of the game was the same throughout the entire experimental session. However, participants played in pairs until round 9 and then switched to playing in groups of three. In some of the sessions where framing was not neutral, subjects were also shown a (high or low detail) prompt before they first played the game with vaccination wording. Under the high or low detail conditions, subjects had to read a text about the advantages of vaccination, that either included numerical digits or only wording. In the online Supplementary Material we provide the complete statements for all wordings.

In each main block where they played the three players version, we divided the participants in 3 equal groups (numbered 1, 2, 3 in Table 2) and also the rounds were divided in 3 equal sub-blocks. Subjects were rotated to play as either the active or the passive player, so that each group of subject played the passive role for an entire sub-block of rounds. So, in the main blocks in which we have 3- players, in the first sub-block of rounds none of the active players had experienced the condition of being passive, half of them had this experience in the second sub-block, and finally all active players had this experience in the last sub-block.

Table 2 shows this rotation within each main block variant, where we have assigned ID's 1,2, and 3 to the three groups of players. Subjects did not know the group in which they were, but they could see during the rounds if they were active or passive. In the cases in which both variants main blocks had three players, we chose to change group composition from the first to the second main block, so as not to leave room for retaliation against opponents in the previous round. More information about the laboratory experiment recruitment and implementation process can be found in the Appendix.

We assumed that participants might cooperate conditionally, meaning that the likelihood they cooperate increases in response to the (perceived) likelihood that others cooperate. In order to measure the perception of others cooperating, we elicited the belief of each participant in every round about the action of other active subjects in the same room (who were not in their group in that given round, and therefore whose actions were unobservable). Subjects were asked to guess the number of active players in the room who they thought chose the cooperative action (Choice 1 or Vaccinate, depending on the framing) in the game they had just played.

Payoffs were given in experimental tokens (maximum 10 for each instance of both the belief elicitation exercise and the game) which were converted, at the end of the experiment, at a conversion rate known to subjects. The final payoff was determined by randomly selecting 4 rounds from the overall 30 that were played by each study participant.

Table 2
Illustrative case of a role allocation procedure for a session with three partecipants who go through the 30 rounds, where the first 9 rounds represent the first main block of the game and the remaining 21 rounds represent the second main block. The three participants are labelled with the IDs 1, 2 and 3 and are allocated to one role in each block of rounds (eg. participant no. 3 plays as an active player in the first three rounds, as a passive player in the second 3 rounds and as active again in the last 3 rounds of the first main block and similarly over the second main block of the game).

Game Type	Rounds	Player's role in the game		
		Active	Active	Passive
First main block	1–3	3	1	2
	4–6	1	2	3
	7–9	2	3	1
Second main block	10–16	3	1	2
	17–23	1	2	3
	24–30	2	3	1

For each of these four rounds, we randomly assigned as the final payoff either the outcome of the game, given the players' decisions, or the payoff obtained by the same individual from the belief elicitation exercise. At the end of the session, the corresponding experimental tokens earned were summed and converted to euros at a rate of 1 token = 0.50 Euros (maximum payoff per round was 5 Euros). In addition, participants received a participation fee of 5 Euros and the maximum overall amount that they could receive at the end of the experiment was 25 Euros. The experiment was completely anonymous and study participants were paid with Amazon gift cards.

2.3. Data analysis

Our outcome of interest is the action of players in each round of their session: whether they played the cooperative or the uncooperative action. Two types of sessions were run: one in which we kept the number of players fixed and changed framing, and one in which we kept the framing and changed the number of players. Only in the 3-player scenario, we have our treatments of interest: the presence of a third player and also the experience of having been passive. Moreover, given the effect of rounds (Figure A1 in the Appendix), our treatment variables were correlated with our controls and with the rounds.

Covariate balance checks are provided in the Appendix whereby we report separately uptake of the cooperative action for each control/treatment variable at the participant-round level. Since balance does not hold for all covariates obtained from the survey, we present robustness checks where we control for these covariates in the regressions (see Appendix for details). More information on the measurement of the control variables and summary statistics on the sample can also be found in the Appendix.

The main treatment variables that we consider in the model specification are the following: a treatment that is an indicator for the presence of a third player (0 if two-player game is played, 1 if three-player game is played) and a treatment that is an indicator of whether that subject had been previously passive (0 if the subject had not been previously passive, 1 if she/he had been previously passive). Indeed, by construction, in the 2-to-3 players' sessions (session numbers: 6–10, 13–16, see Table 1), no active player had any passive experience in rounds 10–16; in rounds 17–23, one half of the active players had been passive before; by round 24, all active players had some previous passive player experience.[1] Minor treatments that we use as controls, as discussed above, are the framing (0 if neutral, 1 if vaccination), and the exposure to a low detail prompt (1 if low detail prompt is provided, 0 if no prompt) or to a high detail prompt (1 if high detail prompt is provided, 0 if no prompt).

After each round every subject had to guess how many other active players had played the cooperative action in that round.

Perceived cooperation refers to this personal guess, expressed in round numbers by the subject, about how many other active players' were playing the cooperative action in that round (see details in the Appendix). We have then normalized this guess as the percentage of other subjects that the participant believes are cooperating, so that the regressor runs from 0 to 1, to homogenize across the session which were not uniform in the number of subjects.

We consider also session fixed effects for our 16 sessions, which control for the fact that the composition of subjects' behavior in each experimental session is different and may affect the overall evolution of behaviors.

Among the 374 participants, we collected 328 complete surveys before the experiment, and we use some of that information as

[1] Conversely, in the 3 players sessions (session numbers: 3–5, 11–12, see Table 1) no active player had any passive experience in rounds 1–3; in rounds 4–6, one half of the active players had been passive before; by round 7, all active players had some previous passive player experience.

additional controls. In the Appendix we provide descriptive statistics on those variables.

3. Results

A total of 374 subjects participated in 16 sessions. The average uptake values of study partecipants varied from 35% to 48%, depending on different controls and treatments (Tables A2 and A3). However, given the complexity of the experimental design, it was not possible to find the direct treatment effects from a simple comparison of means.

In Fig. 2 we show model estimates using a reduced set of controls and in Table 3, we show estimates using a two-level linear probability and probit models, with an expanding set of controls and clustered errors, where we pool together all our observations (see also Tables A5-A6 in the Appendix).

As anticipated, when discussing the effect of rounds, there is a negative effect of experience, which is significant in some of the model specifications, as every additional round of the game reduces the probability of collaborating by around 1–3 percentage points (Fig. 2 below), in line with what happens typically in repeated behavioral experiments (on this, see for example Andreoni, 1988, or Fischbacher, and Gachter, 2010). This effect is important because it implies correlation of the major and the minor treatments, that are themselves correlated with the flow of rounds because of the sessions' design.

The first two columns of each model specification (linear or probit) in Table 3 show that the presence of a third passive player alone does not have a clear effect. The reference condition is two-player, neutral wording, no detail, where the average uptake was the lowest one at 0.44 and where the effect of a third player was the highest one (see Fig. 2 and Table A2 in the Appendix). For this reason, we find a negative coefficient for the presence of a third player in the first columns, which becomes positive and significant only when we interact it with framing and prompt and we add controls.

Conversely, a strong pervasive and robust effect is found when considering the experience of being passive, which increases the probability of cooperation by around 30 percentage points with the simple model of Fig. 2 and by 46 percentage points in all the specifications in Table 3. These results are remarkably robust to changes in the model specification and to the inclusion of various controls (as shown in the Appendix).

Perceived cooperation is also found to have a strong and significant effect. We have computed that for each additional subject in the same session that the player thinks is cooperating, there is an increase in the individual's probability of uptake of 1–2%.

As for the rest of the controls variables, vaccination wording has a significant positive effect on vaccine uptake that, however, reduces its significance as other controls, time interactions and individual characteristics are included in the model specification. The linear estimates are not statistically significant. The estimated coefficients of the vaccination prompt, be it low or high detail, are insignificant, which suggests that they have no impact on cooperation.

The probit estimates indicate an overall significant positive effect of vaccination wording, an increase of 9 percentage points in cooperation/vaccine uptake (all marginal effects are in Table A7 in the Appendix).

Additional tables showing the crude cooperation/vaccine uptake averages by control and treatment, marginal effects and various robustness checks are presented in the Appendix (Table A2, A3, and A7).

4. Discussion

Findings from our laboratory experiment offer three novel insights into the dynamic relationship between messaging strategies invoking altruistic behavior and vaccination intentions. First, our findings suggest conveying how actions affect the wellbeing of vulnerable groups may be an effective way of triggering more altruistic actions from individuals considering getting vaccinated.

Second, they reveal that individuals who, at one time, belonged to a vulnerable group, are more inclined to vaccinate than those without such experience. Third, we show that subjects vaccinate more when they believe others vaccinate at higher rates. Our results also suggest vaccine

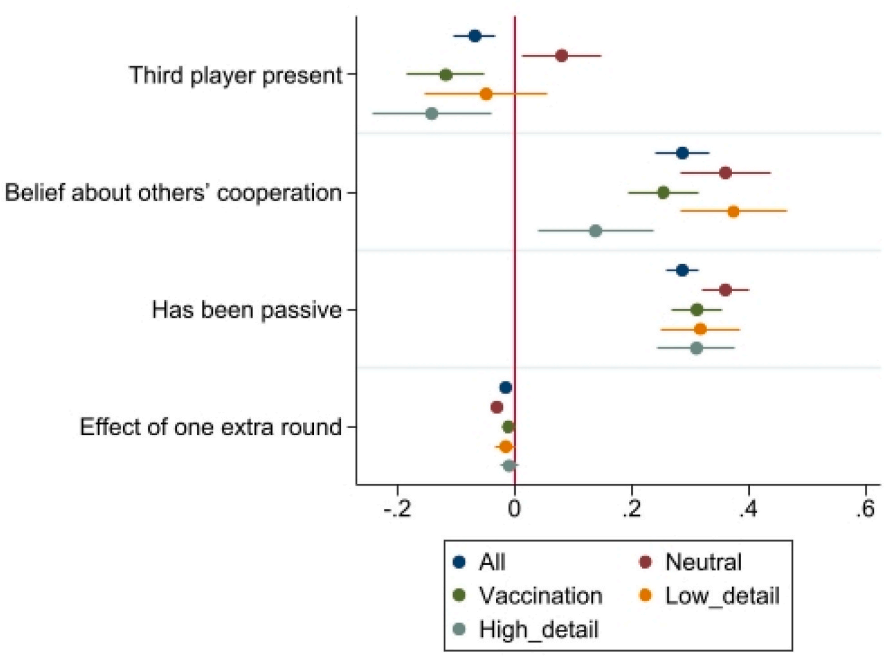

Fig. 2. Graphical representation of the estimated coefficients of a simple regression model where the dependent variable is vaccination uptake and the sample has also been stratified according to the characteristics of the game. Vaccination and Neutral refer to the wording, while Low detail and High detail refer to the prompt within vaccination wording. "Neutral" and "Vaccination" are a partition of "All". See Table A4 in the Appendix for additional details. Bars indicate the 95% confidence interval.

Table 3
Two-Level Linear and Probit Estimates. Data from a laboratory experiment with Italian University students (standard errors in parentheses).

	Dependent variable: vaccination uptake							
	Model: linear				Model: probit			
Third player present (3)	−0.0354	−0.0288	0.282***	0.274***	−0.107	−0.0890	0.985***	0.984***
	(0.0224)	(0.0237)	(0.0695)	(0.0743)	(0.0661)	(0.0701)	(0.220)	(0.237)
Vaccination wording (V)	0.115***	0.0921**	0.0509	0.0478	0.346***	0.279**	0.331	0.347
	(0.0334)	(0.0374)	(0.0998)	(0.107)	(0.0991)	(0.111)	(0.313)	(0.340)
Vaccination wording, low detail prompt (VLD)	−0.0257	0.00973	0.0370	0.00276	−0.0963	−0.00430	0.0418	−0.0803
	(0.0375)	(0.0413)	(0.117)	(0.125)	(0.110)	(0.122)	(0.369)	(0.395)
Vaccination wording, high detail prompt (VHD)	−0.0375	−0.0162	0.0510	0.0786	−0.124	−0.0579	0.0975	0.156
	(0.0345)	(0.0391)	(0.0974)	(0.104)	(0.102)	(0.116)	(0.306)	(0.331)
Belief about others' cooperation			0.281***	0.306***			0.859***	0.941***
			(0.0277)	(0.0296)			(0.0891)	(0.0957)
Has been passive			0.460***	0.455***			1.493***	1.483***
			(0.0161)	(0.0168)			(0.0553)	(0.0583)
Session fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Round (quadratic)	✓	✓	✓	✓	✓	✓	✓	✓
Treatment interactions (3*V, 3*VLD, 3*VHD)			✓	✓			✓	✓
Interactions with time (round); linear and quadratic			✓	✓			✓	✓
Demographic controls		✓		✓		✓		✓
Health controls		✓		✓		✓		✓
Risk and social preferences controls		✓		✓		✓		✓
Observations	11,220	9840	11,220	9840	11,220	9840	11,220	9840
Number of participants	374	328	374	328	374	328	374	328

Standard errors in parentheses.
* $p < 0.10$,** $p < 0.05$,***$p < 0.01$.
3*V Third player present*vaccination wording 3* VLD Third player present*vaccination wording with low detail prompt 3* VHD Third player present*vaccination wording with high detail prompt.

specific narratives do not significantly affect uptake, in line with Nyhan et al. (2013, 2014).

Taken together, these findings make important contributions to vaccine hesitancy theory and practice. With respect to theory, our findings show that not only are individuals responsive to altruistic messaging, but also that certain characteristics of the individual (i.e., past experience being vulnerable) and their perceptions of social norms (i.e., belief that others vaccinate) also weigh on vaccination decisions. One explanation for why past experience as the vulnerable player is so critical to vaccination intentions is that it may contribute to greater empathy with the plight of those unable to vaccinate. This aligns with research on the empathy-altruism hypothesis, which argues that "empathetic concern produces altruistic motivation" that may trigger decisions to vaccinate to help those unable to do so (Batson et al., 2015: 260). We also find that the neutral framing is more effective than the vaccination wording for the third player scenario, with the difference driven by a strong negative reaction to the high detail wording for the vaccination treatment (in Fig. 2 and Table A4 in the Appendix). These findings align with previous work that examines vaccine messaging effectiveness through a lens of cognitive load theory. A key finding from this work is that the inclusion of details in messages encouraging vaccination suppresses forms of comprehension that are essential to persuading members of the public to vaccinate (Porumbescu et al., 2020). In other words, attempting to persuade the public to vaccinate through the use of facts may backfire. With respect to practice, offer recommendations related to steps that can be taken to increase the effectiveness of efforts to reduce vaccine hesitancy and increase vaccination intentions. For example, crafting messages that emphasize how many have already vaccinated and who benefits from vaccination may be effective strategies. Considering our results, drawing up experiences from the past of having been vulnerable may also be an effective strategy for inspiring altruistic behavior: define messaging campaigns invoking past experiences of dependence and vulnerability can increase vaccination intentions. These contributions notwithstanding, our findings should be interpreted in light of limitations that pave the way for future research. One initial limitation relates to the nature of our sample. The experiment was conducted with students of an Italian University who are young and therefore unlikely to have real-world experience with being dependent on others from an immunisation perspective. A future research direction worth pursuing is to replicate our experiment with other subjects to investigate any moderating effects due to students status. A second limitation pertains to the fact that our study was conducted in a laboratory setting, which raises questions over the extent to which our findings will translate into a real world context. While various measures were taken to mimic a real-world decision-making environment, to truly examine the generalizability of our findings field experiments in real world settings are needed. A third limitation relates to the complexity of the experiment. However, if on one side we are aware that this complex design precludes some direct comparisons among treatments, on the other side this allows us to study the effects of learning in an environment where, for each subject, only one major or minor treatment changed during the experiment. A fourth potential limitation of this study relates to the possible role of social context and (limited) experience with outbreaks plays in shaping relationships we have identified. To this end, it would be interesting to examine whether the findings we have uncovered in our study, conducted in the pre-coronavirus era where most of the population only had limited experiences with outbreaks, generalize to the post-coronavirus era, where nearly the entire population has directly or indirectly been touched by a virus that is now considered a VPD.

This last point is especially poignant in light of the recent release of a coronavirus vaccine. While scientists appear to have succeeded in the monumental task of developing a vaccine for coronavirus in less than a year, the world is now grappling with the equally important question of how to convince a hesitant public to vaccinate and to continue to engage in behaviors that safeguard those unable to vaccinate until herd immunity is reached (Ball, 2020). For such a complex public health issue, a single solution is unlikely. Rather, governments will need to develop a portfolio of policy tools targeting vaccination hesitance, which will likely include different incentives, especially among those who perceive risks of coronavirus as being low. While the findings from this study are unable to directly map onto coronavirus vaccine behaviors, they do suggest governments would be wise to consider supplementing appeals to individual self-interest with altruistic messaging, social norm cues, and invoking memories of past vulnerability in their efforts to encourage individuals to vaccinate.

Declaration of competing interest

None.

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Appendix 1

1. . Methods and Materials

1.1. Experiment in the University Lab

1.1.1. Recruitment. Participants were students at an Italian university, recruited in April 2018 via an experimental laboratory recruitment system. In the invitation email, we sent subjects a link to the online Qualtrics survey, explaining that if they had not filled in the survey before the laboratory session, they would not be allowed to participate. Upon finishing the survey, subjects received a random number that they had to present before they could enter the laboratory. The laboratory experiment itself was conducted May 3–10, 2018, with some pilot sessions run on May 3. Participants played forty rounds of the games on May 3 (pilot sessions), and thirty rounds on later days on a computer, at separate stations. The sessions were made shorter in order to comply with the laboratory schedule. To make the data comparable across sessions, observations pertaining to rounds 10, and 31–40 were discarded for the sessions that had 40 rounds so as to align the data structure with the later sessions of 30 round containing 9 rounds of the first variant main block of the game played and 21 rounds of the second variant of the game played main block. The experiment was completely anonymous. We ran five sessions per day on May 3, May 7, and May 8, and two sessions per day on May 9 and 10. We discarded data from the first three sessions on May 3 because of technical problems that occurred during those sessions that made us discard the data.

1.1.2. Payment. Study participants were paid with Amazon gift cards. In particular, at the end of the experiment, subjects were asked to sign a receipt for the gift card, corresponding to their earnings (details below), which was mailed to them by Amazon within a few weeks after the experiment. Since the laboratory had 27 stations and we needed the number of participants to be a multiple of six for some sessions, there were a few participants who had filled in the survey but could not participate in the laboratory session. They were paid 5 euros as a show-up fee using the same Amazon gift card process. The maximum amount paid overall was 25 euros. Subjects who participated in pilot sessions that were not used in the analysis were paid and those who took part in sessions we used data from were paid according to the same procedure.

More precisely, players had two tasks to make at each round: the actual game and a guess on how many other active players had played the cooperative action in that round. With the game they could earn a maximum of 10 tokens. In the guessing task, at the end of each round, subjects were asked to select an integer (on a sliding scale) between 0 and M, where M was the number of active players in the game excluding those two that were present in the participant group given by the formula

$$M = \left\{ \begin{array}{ll} \dfrac{number\ of\ players\ in\ session}{number\ of\ active\ players} - \underbrace{2}_{active\ players\ in\ own\ group}, & if\ 2\ player\ game \\ \dfrac{number\ of\ players\ in\ session*2/3}{number\ of\ active\ players} - \underbrace{2}_{active\ players\ in\ own\ group}, & if\ 3\ player\ game \end{array} \right\}$$

Correct guesses were incentivized through a belief elicitation exercise whereby we assigned to players a payoff which was inversely related to the distance between the individual's guess and the actual number of players who choose the cooperative action

$$payoff = max\left\{0, 10 - \left| player's\ guess\ - \sum_{number\ active-2} 1_{Choice\ 1/Vaccinate} \right| \right\}$$

where 10 represents the maximum payoff that could be generated here.

At the end of the experiment, for each subject, we randomly drew 4 rounds and for each of them we payed to the participant either the actual game or the guess elicitation task. Since the maximum that could be earned in each round was 10 tokens, and we converted 1 token with 0.50 Euros, the maximum earning for each round was 5 Euros.

1.1.3. Controls. We also collected data on the participants' individual characteristics that we believe could affect their behavior in the game, including demographics, health, and social preferences variables. Demographic controls are gender, political views, religiousness, and highest education achieved. Health variables include self-assessed general health (measured 0–100), the number of medical check-ups in the past year, the number of influenza shots received in the past 5 years, and an indicator if the subject's doctor has ever advised him or her not to vaccinate against some disease. Social preferences are self-reported risk aversion, multiple price-list measured risk aversion, a categorical variable measuring positive reciprocity, self-reported altruism and a quantitative (donation-based) measure of altruism. The survey instruments used to measure these variables were taken from a set of validated survey items by Falk et al. (2016). We asked subjects to fill in a survey on Qualtrics aimed at finding out about their vaccination attitudes prior to the laboratory experiment. We also added question measuring risk aversion, altruism, and positive reciprocity from the Preference Module Laboratory Version by Falk et al. (2016), The Preference Survey Module: A Validated Instrument for Measuring Risk, Time, and Social Preferences, IZA Discussion Paper No. 9674. Some questions were directly taken from the Preference Module: Question 1 for risk aversion, Questions 7 and 8 for altruism, and Question 9 for positive reciprocity. We also used a modified version of Question 2 to measure risk aversion. We use some survey items as controls in the analysis, i. e gender, education, political view, self-evaluation of health condition, religious belief. The full survey will be made available upon request.

1.1.4. Ethics. The experimental design was approved by Bocconi University Ethics Committee.

1.1.5. Summary Statistics. Summary statistics of the covariates used from survey date can be found in Table A 1. The mean value of 152 Euros that our subjects would donate to a hypothetical charity is low compared to a general population, but it should be considered that we have a population of university students.

Table A1
Summary Statistics, Students

Continuous variables	Mean	Standard deviation
Altruism, donation (0–1000)	152.851	177.006
Risk aversion, price list (2.6–9.4)	6.634	2.150
General health (0–100)	76.046	14.850
Flu shot number	1.512	1.692
N	328	
Categorical variables	**N**	**Column %**
Male		
No	151	46.0%
Yes	177	54.0%
Highest education achieved		
High school	246	75.0%
Undergraduate	65	19.8%
Graduate	17	5.2%
Political views		
Strong liberal	31	9.5%
Moderate liberal	203	61.9%
Moderate conservative	53	16.2%
Strong conservative	4	1.2%
Populist	6	1.8%
Libertarian	15	4.6%
Other	16	4.9%
Religiousness		
No	243	65.0%
Yes	131	35.0%
Number of medical check-ups in the past year		
None	124	37.8%
1	107	32.6%
2	62	18.9%
3	18	5.5%
3+	17	5.2%
Doctor ever advised not to vaccinate		
No	308	93.9%
Yes	20	6.1%

(*continued on next page*)

Table A1 (*continued*)

Continuous variables	Mean	Standard deviation
Self-reported willingness to share (0–10)		
0	16	4.9%
1	31	9.5%
2	32	9.8%
3	31	9.5%
4	30	9.1%
5	24	7.3%
6	31	9.5%
7	57	17.4%
8	46	14.0%
9	18	5.5%
10	12	3.7%
Positive reciprocity (1–6)		
1	36	11.0%
2	81	24.7%
3	81	24.7%
4	60	18.3%
5	47	14.3%
6	23	7.0%
Self-reported risk loving (0–10)		
0	8	2.4%
1	12	3.7%
2	30	9.1%
3	41	12.5%
4	39	11.9%
5	22	6.7%
6	50	15.2%
7	61	18.6%
8	48	14.6%
9	13	4.0%
10	4	1.2%
Total	328	100.0%

1.1.6. Baseline Cooperation/Vaccine Uptake by Control. See the cooperative choice/vaccine uptake decision averages in Table A2 and Table A3.

TableA2
Average Uptake by Control, Number of Players Varies

	2 players	3 players	Difference
Neutral wording	0.44	0.35	−0.09
	(0.50)	(0.48)	(0.02)
Vaccination wording, no prompt	0.48	0.34	−0.14
	(0.50)	(0.47)	(0.05)
Vaccination wording, low detail prompt	0.45	0.36	−0.09
	(0.50)	(0.48)	(0.04)
Vaccination wording, high detail prompt	0.45	0.34	−0.11
	(0.50)	(0.47)	(0.03)

Standard deviation in parentheses.

Table A3
Average Uptake by Control, Wording Varies

	Neutral wording	2 players Vaccination wording	Difference	Neutral wording	3 players Vaccination wording	Difference
No prompt	0.44	0.48	0.03	0.35	0.34	−0.01
	(0.50)	(0.50)	(0.05)	(0.48)	(0.47)	(0.03)
Low detail prompt	0.44	0.45	0.01	0.35	0.36	0.01
	(0.50)	(0.50)	(0.04)	(0.48)	(0.48)	(0.02)
High detail prompt	0.44	0.45	0.01	0.35	0.34	−0.01
	(0.50)	(0.50)	(0.04)	(0.48)	(0.47)	(0.02)

Standard deviation in parentheses.

1.1.7. Pure effects of rounds

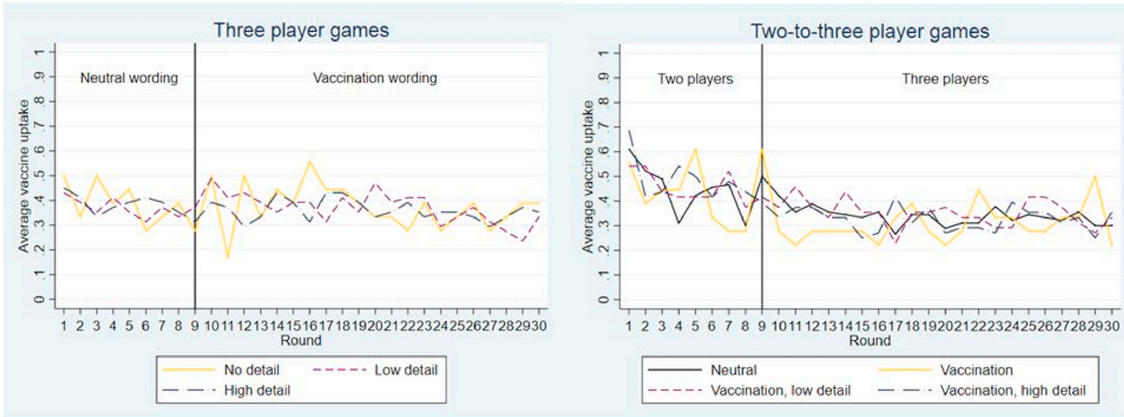

Fig. A1. Uptake level with respect to rounds, averaged across sessions, for those sessions where we kept three players and changed wording (left) and in the case in which we moved from two to three players (right). Both havea decreasing trend, which is evident in the right panel.

1.1.8. Vaccination uptake: linear model. Table A4 shows the outcome of a simple linear model, with session fixed effects, on the probability of playing the cooperative action (a graphical representation is included in the main text, Fig. 2). In order to provide a clearer interpretation, we have also divided the pool of all our observations between neutral wording and vaccination wording (second and third columns) and then, among the latter, those with low detail and high detail specification (last two columns).

Table A4
Simple linear estimates for the whole sample and for different wording, with session fixed effects (standard errors in parentheses). The entire sample is partitioned in two groups: Neutral and Vaccination wording.

	Vaccination uptake: linear model				
	Wording				
	All	Neutral	Vaccination	Vaccination low detail*	Vaccination high detail*
Third player present	−0.068	0.081	−0.117	−0.048	−0.142
	(0.018)	(0.035)	(0.034)	(0.054)	(0.052)
Belief about others' cooperation	0.287	0.361	0.255	0.375	0.138
	(0.024)	(0.039)	(0.030)	(0.047)	(0.050)
Has been passive	0.287	0.361	0.313	0.318	0.311
	(0.014)	(0.021)	(0.022)	(0.034)	(0.034)
Effect of one extra round	−0.015	−0.030	−0.010	−0.015	−0.009
	(0.003)	(0.005)	(0.005)	(0.008)	(0.008)
Session fixed effects	yes	yes	yes	yes	Yes
Observations	11,220	4230	6990	2511	3057

[*] Vaccination Low and High detail are disjoint subset of the rounds with the Vaccination framing (the Vaccination column includes High details, Low details and No prompt).

1.1.9. Estimation strategy. We estimated two-level mixed effects models in the general form:

$$Pr(y_{ri} = 1|x_{ri}) = H(x_{ri}\beta + z_{ri}u_i)$$

where $y_{ri} = 1$ is the cooperative action (Choice 1/Vaccinate), $r = 1, \ldots, 30$ denotes rounds, $i = 1, \ldots, I$ denotes subjects with $I = 374$ when no survey data is used and $I = 328$ when matched data is used, x_{ri} are the fixed effects with regressions coefficients β and z_{ri} are the covariates corresponding to the random effects. If $z_{ri} = 1$, the resulting model is with random intercepts: we allow the error term to vary across individuals. More generally, the random effects u_i are I realizations from a multivariate normal distribution with mean 0 and variance Σ. The random effects are not directly estimated as model parameters but are instead summarized according to the unique elements of Σ, known as variance components. Intuitively, random coefficient models allow for a heterogeneous response to controls and treatments. Finally, H is the identity function for the linear specification and the standard normal cumulative distribution function $H(v) = \Phi(v)$ for probit.

Table A5 and Table A6 below report estimates with an expanding set of controls for the laboratory experiment, including treatment interactions, interactions with the time variable (rounds of the game) to capture effects that result from learning or experience, and interactions with a quadratic of the time variable to capture any nonlinearities in the response to experience. In these tables the belief about others' cooperation has been normalized between 0 and 1. We present results for two-level linear probability model and probit. Random intercepts are included.

The corresponding marginal effect of the third player presence, as reported in Table A7, is significant and negative, ranging from -0.21 to -0.47, with a full set of controls. This signals an overall negative impact on cooperation, which is driven by the interaction of the third player presence and vaccination wording. The sign and significance of the estimated coefficients is consistent across linear and probit specifications, with the probit estimates being higher in magnitude. Estimates based on specifications that also include random coefficients, i.e. a measure of individual heterogeneity in the response to controls and treatments, are available upon request. We found that the results are quite robust to the inclusion of random coefficients.

We have also run all the regressions with a specification in which the 'has been passive' variable could be either 'has been passive once' or 'has been passive twice', to account for Sessions 3, 4, 5, 11 and 12, where all rounds were with the 3-players game. Also in this last case the results are analogous and available upon request. Balance checks also are available upon request.

Table A5
Two-Level Linear Estimates

	Dependent variable: vaccination uptake									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Third player present (3)	−0.0354	−0.0288	−0.0264	−0.0317	0.0233	0.0136	0.298***	0.276***	0.282***	0.274***
	(0.0224)	(0.0237)	(0.0253)	(0.0266)	(0.0246)	(0.0258)	(0.0509)	(0.0539)	(0.0695)	(0.0743)
Vaccination wording (V)	0.115***	0.0921**	0.130***	0.100**	0.210***	0.163***	0.139**	0.165**	0.0509	0.0478
	(0.0334)	(0.0374)	(0.0367)	(0.0433)	(0.0356)	(0.0418)	(0.0658)	(0.0735)	(0.0998)	(0.107)
Vaccination wording, low detail prompt (VLD)	−0.0257	0.00973	−0.0520	−0.0250	−0.222***	−0.189***	−0.0265	−0.0764	0.0370	0.00276
	(0.0375)	(0.0413)	(0.0494)	(0.0549)	(0.0481)	(0.0532)	(0.0755)	(0.0820)	(0.117)	(0.125)
Vaccination wording, high detail prompt (VHD)	−0.0375	−0.0162	−0.0278	−0.0182	−0.0752*	−0.0664	0.0126	−0.0297	0.0510	0.0786
	(0.0345)	(0.0391)	(0.0404)	(0.0475)	(0.0390)	(0.0458)	(0.0625)	(0.0703)	(0.0974)	(0.104)
Round	−0.0133***	−0.0128***	−0.0133***	−0.0128***	−0.0233***	−0.0230***	−0.0153***	−0.0148***	−0.0722***	−0.0722***
	(0.00337)	(0.00359)	(0.00337)	(0.00359)	(0.00329)	(0.00351)	(0.00484)	(0.00523)	(0.0213)	(0.0231)
Round squared	0.000274***	0.000240***	0.000274***	0.000240***	0.000318***	0.000278***	0.000504***	0.000467***	0.00619***	0.00621***
	(0.0000865)	(0.0000922)	(0.0000864)	(0.0000922)	(0.0000836)	(0.0000889)	(0.000104)	(0.000110)	(0.00208)	(0.00225)
3*V			−0.0345	−0.0146	−0.167***	−0.139***	−0.285***	−0.322***	−0.490**	−0.552**
			(0.0355)	(0.0386)	(0.0346)	(0.0375)	(0.0772)	(0.0827)	(0.208)	(0.216)
3*VLD			0.0461	0.0412	0.131***	0.129***	0.0841	0.180*	0.157	0.172
			(0.0431)	(0.0462)	(0.0417)	(0.0446)	(0.0890)	(0.0942)	(0.237)	(0.247)
3*VHD			−0.00246	0.00584	0.0285	0.0470	0.0145	0.0655	−0.0874	−0.0469
			(0.0405)	(0.0441)	(0.0391)	(0.0425)	(0.0793)	(0.0847)	(0.228)	(0.238)
Belief about others' cooperation					0.277***	0.304***	0.278***	0.305***	0.281***	0.306***
					(0.0278)	(0.0297)	(0.0277)	(0.0296)	(0.0277)	(0.0296)
Has been passive					0.383***	0.389***	0.456***	0.450***	0.460***	0.455***
					(0.0149)	(0.0156)	(0.0161)	(0.0168)	(0.0161)	(0.0168)
Round*3							−0.0273***	−0.0261***	0.0181	0.0180
							(0.00577)	(0.00620)	(0.0221)	(0.0238)
Round*3*V							0.0153**	0.0192***	−0.00477	−0.00153
							(0.00680)	(0.00742)	(0.0316)	(0.0337)
Round*3*VLD							−0.00286	−0.0101	0.00619	0.00184
							(0.00946)	(0.0101)	(0.0442)	(0.0466)
Round.3*VHD							0.000644	−0.00204	0.0141	0.0191
							(0.00451)	(0.00508)	(0.0260)	(0.0276)
Round*V							−0.00247	−0.00584	0.0548**	0.0583**
							(0.00612)	(0.00674)	(0.0239)	(0.0261)
Round*VLD							0.000356	0.00516	−0.0226	−0.0129
							(0.00896)	(0.00957)	(0.0380)	(0.0403)
Round*VHD							−0.00234	0.0000591	−0.00790	−0.0190
							(0.00334)	(0.00399)	(0.0127)	(0.0145)
Round squared *3									−0.00538***	−0.00538**
									(0.00209)	(0.00226)
Round squared *3*V									0.00477**	0.00486**
									(0.00216)	(0.00234)
Round squared *3*VLD									−0.00194	−0.00121
									(0.00361)	(0.00381)
Round squared *3*VHD									−0.000357	−0.000636
									(0.000669)	(0.000721)
Round squared *V									−0.00572***	−0.00598***
									(0.00210)	(0.00228)
Round squared *VLD									0.00229	0.00137
									(0.00357)	(0.00376)
Round squared *VHD									0.000161	0.000584
									(0.000364)	(0.000424)
Constant	0.511***	0.468***	0.500***	0.462***	0.450***	0.354***	0.352***	0.240*	0.450***	0.330**
	(0.0456)	(0.125)	(0.0469)	(0.125)	(0.0498)	(0.130)	(0.0542)	(0.134)	(0.0665)	(0.141)
Session fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Demographic controls		✓		✓		✓		✓		✓
Health controls		✓		✓		✓		✓		✓
Risk and social preferences controls		✓		✓		✓		✓		✓
Observations	11,220	9840	11,220	9840	11,220	9840	11,220	9840	11,220	9840
Number of participants	374	328	374	328	374	328	374	328	374	328

Standard errors in parentheses.
*p < 0.10, **p < 0.05, ***p < 0.01.

Table A6
Two-Level Probit Estimates

	Dependent variable: vaccination uptake									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Third player present (3)	−0.107 (0.0661)	−0.0890 (0.0701)	−0.0777 (0.0745)	−0.0936 (0.0785)	0.0603 (0.0769)	0.0316 (0.0811)	1.010*** (0.162)	0.952*** (0.172)	0.985*** (0.220)	0.984*** (0.237)
Vaccination wording (V)	0.346*** (0.0991)	0.279** (0.111)	0.399*** (0.110)	0.313** (0.131)	0.688*** (0.113)	0.542*** (0.135)	0.545*** (0.210)	0.660*** (0.237)	0.331 (0.313)	0.347 (0.340)
Vaccination wording, low detail prompt (VID)	−0.0963 (0.110)	0.00430 (0.122)	−0.177 (0.147)	−0.102 (0.164)	−0.709*** (0.152)	−0.612*** (0.170)	−0.114 (0.239)	−0.302 (0.263)	0.0418 (0.369)	−0.0803 (0.395)
Vaccination wording, high detail prompt (VHD)	−0.124 (0.102)	−0.0579 (0.116)	−0.105 (0.121)	−0.0700 (0.143)	−0.245** (0.123)	−0.211 (0.147)	0.0257 (0.199)	−0.144 (0.226)	0.0975 (0.306)	0.156 (0.331)
Round	−0.0387*** (0.00991)	−0.0372*** (0.0106)	−0.0387*** (0.00991)	−0.0373*** (0.0106)	−0.0736*** (0.0103)	−0.0732*** (0.0111)	−0.0474*** (0.0150)	−0.0456*** (0.0163)	−0.217*** (0.0663)	−0.218*** (0.00722)
Round squared	0.000795*** (0.000255)	0.000692** (0.000273)	0.000794*** (0.000255)	0.000692** (0.000273)	0.00101*** (0.000263)	0.000883*** (0.000282)	0.00167*** (0.000334)	0.00155*** (0.000356)	0.0186*** (0.00646)	0.0187*** (0.00703)
3*V			−0.116 (0.105)	−0.0568 (0.116)	−0.547*** (0.109)	−0.459*** (0.120)	−1.006*** (0.247)	−1.159*** (0.268)	−1.684** (0.663)	−1.981*** (0.693)
3*VLD			0.144 (0.128)	0.129 (0.138)	0.433*** (0.132)	0.430*** (0.143)	0.280 (0.283)	0.600** (0.302)	0.442 (0.756)	0.531 (0.791)
3*VHD			0.00778 (0.120)	0.0257 (0.132)	0.114 (0.123)	0.160 (0.136)	0.0947 (0.253)	0.272 (0.273)	−0.224 (0.727)	0.0157 (0.763)
Belief about others' cooperation					0.841*** (0.0883)	0.925*** (0.0949)	0.850*** (0.0890)	0.934*** (0.0955)	0.859*** (0.0891)	0.941*** (0.0957)
Has been passive					1.212*** (0.0492)	1.238*** (0.0521)	1.473*** (0.0549)	1.461*** (0.0578)	1.493*** (0.0553)	1.483*** (0.0583)
Round*3							−0.0944*** (0.0182)	−0.0913*** (0.0196)	0.0371 (0.0687)	0.0357 (0.0747)
Rmmd*3*V							0.0579*** (0.0215)	0.0727*** (0.0237)	0.00966 (0.0996)	0.0277 (0.107)
Round*3*VLD							−0.0128 (0.0297)	−0.0361 (0.0319)	0.0189 (0.139)	0.00588 (0.148)
Round*3*VHD							0.000848 (0.0144)	−0.0101 (0.0164)	0.0399 (0.0829)	0.0437 (0.0885)
Round*V							−0.0136 (0.0193)	−0.0260 (0.0214)	0.150** (0.0743)	0.163** (0.0820)
Round*VLD							0.00601 (0.0280)	0.0217 (0.0303)	−0.0580 (0.119)	−0.0324 (0.127)
Round *VHD							−0.00798 (0.0106)	0.00219 (0.0129)	−0.0181 (0.0400)	−0.0521 (0.0460)
Round squared*3									−0.0159** (0.00647)	-0.0160** (0.00704)
Round squared*3*V									0.0139** (0.00647)	0.0141* (0.00731)
Round squared *3*VLD									−0.00606 (0.0113)	−0.00405 (0.0120)
Round squared *3*VHD									−0.00103 (0.00213)	−0.00167 (0.00232)
Round squared * V									−0.0168*** (0.00652)	−0.0178** (0.00711)
Round squared *VLD									0.00687 (0.0111)	0.00435 (0.0118)
Round squared *VHD									0.000296 (0.00114)	0.00168 (0.00136)
Constant	0.0182 (0.140)	−0.0916 (0.391)	−0.0188 (0.144)	−0.115 (0.394)	−0157 (0.161)	−0.459 (0.436)	−0.488*** (0.176)	−0.842* (0.452)	−0.196 (0.213)	−0.574 (0.473)
Session fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Demographic controls		✓		✓		✓		✓		✓
Health controls		✓		✓		✓		✓		✓
Risk and social preferences controls		✓		✓		✓		✓		✓
Observations	11,220	9840	11,220	9840	11,220	9840	11,220	9840	11,220	9840
Number of participants	374	328	374	328	374	328	374	328	374	328

Standard errors in parentheses
*p < 0.10, **p < 0.05, ***p < 0.01.

Table A7
Marginal Effects

	Dependent variable: vaccination uptake							
	Model:linear				Model:probit			
Third player present (3)	−0.0354	−0.0288	−0.464**	−0.428**	−0.0355	−0.0295	-0.216***	-0.201***
	(0.0224)	(0.0237)	(0.193)	(0.213)	(0.0220)	(0.0233)	(0.0366)	(0.0737)
Vaccination wording (V)	0.115***	0.0921**	−0.0321	0.00134	0.115***	0.0926**	0.0654**	0.0831**
	(0.0334)	(0.0374)	(0.0642)	(0.0584)	(0.0330)	(0.0368)	(0.0323)	(0.0344)
Vaccination wording, low detail prompt (VLD)	−0.0257	0.00973	0.0772	0.0448	−0.0321	0.00143	0.0522	0.0330
	(0.0375)	(0.0413)	(0.0965)	(0.0806)	(0.0367)	(0.0404)	(0.0456)	(0.0526)
Vaccination wording, high detail prompt (VHD)	−0.0375	−0.0162	-0.000406	0.00715	−0.0411	−0.0192	−0.00544	−0.00114
	(0.0345)	(0.0391)	(0.0417)	(0.0445)	(0.0340)	(0.0384)	(0.0394)	(0.0424)
Belief about others' cooperation			0.281***	0.306***			0.259***	0.283***
			(0.0277)	(0.0296)			(0.0267)	(0.0286)
Has been passive			0.460***	0.455***			0.407***	0.403**
			(0.0161)	(0.0168)			(0.0114)	(0.0119)
Session fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
Round (quadratic)	✓	✓	✓	✓	✓	✓	✓	✓
Treatment interactions (3*V, 3*VLD, 3*VLH)			✓	✓			✓	✓
Has been passive, beliefs about others' cooperation			✓	✓			✓	✓
Interactions with time (round); linear and quadratic			✓	✓			✓	✓
Demographic controls		✓		✓		✓		✓
Health controls		✓		✓		✓		✓
Risk and social preferences controls		✓		✓		✓		✓
Observations	11,220	9840	11,220	9840	11,220	9840	11,220	9840
Number of participants	374	328	374	328	374	328	374	328

Standard errors in parentheses.
*p < 0.10, **p < 0.05, ***p < 0.01

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.114195.

Credit author statement

Maria Cucciniello secured funding and proposed the research question. Maria Cucciniello, Paolo Pin, Blanka Imre, Greg Porumbescu, and Alessia Melegaro designed. research. Maria Cucciniello, Paolo Pin, Blanka Imre, Alessia Melegaro performed research. Maria Cucciniello, Paolo Pin, Blanka Imre, Greg Porumbescu, and Alessia Melegaro analysed data. Maria Cucciniello, Paolo Pin, Blanka Imre, Greg Porumbescu, and Alessia Melegaro wrote the paper.

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